

What is claimed is:

- 1 1. A method of forming a Cu alloy, comprising:
2 plating a layer of Cu over a substrate;
3 forming a dopant layer over the Cu layer;
4 driving dopants from the dopant layer into the Cu layer; and
5 removing the dopant layer.
- 1 2. The method of Claim 1, wherein the substrate comprises a diffusion
2 barrier layer overlying a dielectric layer.
- 1 3. The method of Claim 2, wherein the diffusion barrier layer comprises a
2 material selected from the group consisting of Ta, TaN, TaSiN, W, WN, WSiN,
3 Ti, TiN, TiSiN, and Co.
- 1 4. The method of Claim 2, wherein forming the dopant layer comprises
2 plating a layer of metal.
- 1 5. The method of Claim 4, wherein the metal layer comprises at least one
2 element which when alloyed with Cu improves an electromigration characteristic
3 of Cu.

1 6. The method of Claim 5, wherein the at least one element is selected from
2 the group consisting of Sn, Al, Mg, and Co.

1 7. The method of Claim 5, wherein plating the layer of Cu comprises
2 electroplating.

1 8. The method of Claim 5, wherein plating the layer of Cu comprises an
2 electroless deposition.

1 9. The method of Claim 6, wherein driving dopants into the Cu layer
2 comprises elevating the temperature of the dopant layer and Cu layers to
3 between 300°C and 400°C.

1 10. A method of forming a Cu alloy, comprising:
2 plating a layer of Cu over a substrate; and
3 implanting at least one dopant element into the Cu layer.

1 11. The method of Claim 10, wherein the at least one dopant element is
2 selected from the group consisting Al, Mg, and Sn.

1 12. The method of Claim 10, further comprising polishing the layer of Cu so
2 as to form individual interconnect lines prior to implanting.

1 13. The method of Claim 12, further comprising depositing a barrier layer over
2 the interconnect lines subsequent to implanting.

1 14. The method of Claim 13, wherein the barrier layer is formed of a material
2 selected from the group consisting of SiC and SiN.

1 15. The method of Claim 12, further comprising depositing a barrier layer over
2 the interconnect lines prior to implanting.

1 16. The method of Claim 12, wherein the dopant is implanted into the surface
2 of the Cu to depth of about 10 monolayers.

1 17. The method of Claim 12, wherein the dopant is implanted a dose of 3×10^{15}
2 atoms/cm² at an energy of 5keV.

1 18. The method of Claim 12, wherein the dopant is implanted to achieve an
2 implant profile peak at 50 angstroms below the Cu surface and a concentration
3 of 1.5 wt% over 100 angstroms.

1 19. A method of forming a Cu alloy, comprising:
2 depositing a seed layer on a substrate, the seed layer comprising Cu and
3 at least one doping element;

- 4 forming a capping over the seed layer;
- 5 forming a layer of Cu over the capping layer; and
- 6 driving the at least one doping element from the seed layer into the Cu
- 7 layer.

1 20. The method of Claim 19, wherein the seed layer and the capping layer are
2 formed sequentially and without exposing the seed layer to the atmosphere prior
3 to deposition of the capping layer.

1 21. The method of Claim 20, wherein the seed layer and the capping layer are
2 deposited in the same PVD system without breaking vacuum.

1 22. The method of Claim 19, wherein depositing the seed layer comprises
2 sputtering a metal alloy, the metal alloy having at least one element that diffuses
3 in Cu at a temperature less than or equal to 400°C.

1 23. The method of Claim 22, wherein the metal alloy is selected from the
2 group consisting of CuSn and CuMg.

1 24. The method of Claim 22, wherein forming the capping layer comprises
2 sputtering Cu.

1 25. The method of Claim 19, wherein driving the at least one doping element
2 from the seed layer into the Cu layer comprises heating the substrate to
3 temperature in the range of 300°C to 400°C.

1 26. The method of Claim 25, further comprising exposing at least the surface
2 of the Cu layer to an ambient that reacts with the doping element.

1 27. The method of Claim 26, wherein the ambient comprises nitrogen.

1 28. The method of Claim 26, wherein the ambient comprises oxygen.

1 29. The method of Claim 19, wherein the substrate comprises a patterned
2 dielectric layer having a copper diffusion barrier disposed of the surfaces thereof;
3 depositing the seed layer comprises a physical vapor deposition in the absence
4 of oxygen; forming the capping layer comprises a physical vapor deposition of
5 Cu; forming the Cu layer comprises electroplating; and driving the at least one
6 doping element from the seed layer into the Cu layer comprises heating the
7 substrate and, concurrently therewith, exposing the Cu layer to at least one
8 chemical that will react with the at least one doping element such that the at
9 least one doping element is drawn to the surface of the Cu layer.